# PROBABILISTIC LIQUEFACTION POTENTIAL AND LIQUEFACTION-INDUCED GROUND FAILURE MAPS FOR THE URBAN WASATCH FRONT: COLLABORATIVE RESEARCH WITH UNIVERSITY OF UTAH, UTAH STATE UNIVERSITY, AND UTAH GEOLOGICAL SURVEY

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**Barry J. Solomon**
Utah Geological Survey
P.O. Box 146100
Salt Lake City, Utah 84114-6100

Telephone: (801) 537-3388
FAX: (801) 537-3400
E-mail: barrysolomon@utah.gov
URL: http://www.geology.utah.gov/

## INVESTIGATIONS UNDERTAKEN

Liquefaction is a significant seismic hazard for areas underlain by saturated, cohesionless deposits of late Quaternary sands and non-plastic silts. Liquefaction is caused by a loss of shear strength due to the transient rise in excess pore pressure caused by strong earthquake ground motion. Typical manifestations of liquefaction are flow failure, lateral spread, ground oscillation, differential settlement, loss of bearing capacity, ground fissures, and sand boils. Liquefaction-induced ground failure can cause considerable damage to the built environment and loss of life.

Unconsolidated, loose, saturated late Quaternary fluvial, deltaic, flood-plain, fan-delta, lacustrine, playa, colluvial, and dune sediments are moderately to highly susceptible to liquefaction (Youd and Perkins, 1978). These sediments are found along the Wasatch Front urban corridor of Utah, which has a population of about 1.7 million centered upon the Salt Lake City metropolitan area. The presence of potentially liquefiable sediments underlying Wasatch Front valleys, and the potential for large earthquakes on the Wasatch fault zone and other active faults in the region, pose a considerable liquefaction hazard. Local evidence of prehistoric liquefaction includes the North Salt Lake landslides (probable lateral spreads) (Harty and Lowe, 2003) on the northern edge of our study area, and liquefaction features exposed in foundation excavations for the Salt Palace Convention Center expansion in downtown Salt Lake City in the eastern part of our study area (interpreted as either dikes associated with lateral spreading by Korbay and McCormick, 1999, or liquefaction dikes associated with active faulting by Simon and Shlemon, 1999).

This pilot project will develop state-of-the-art methods for liquefaction-hazard and lateral-spread-displacement analyses and apply the methods using a geographic information system to produce probabilistic liquefaction-hazard-potential maps for northern Salt Lake Valley (figure 1). The role of the Utah Geological Survey (UGS) in this pilot project is to identify representative geotechnical parameters for surficial geologic units and assess the nature of underlying units. This information will be used in the pilot project to modify mapped liquefaction-hazard-potential boundaries and extend hazard mapping to areas having little or no subsurface data. Pilot-study geologic information will then be used in future studies to assist in mapping liquefaction-hazards in other areas along the Wasatch Front with little or no subsurface data.

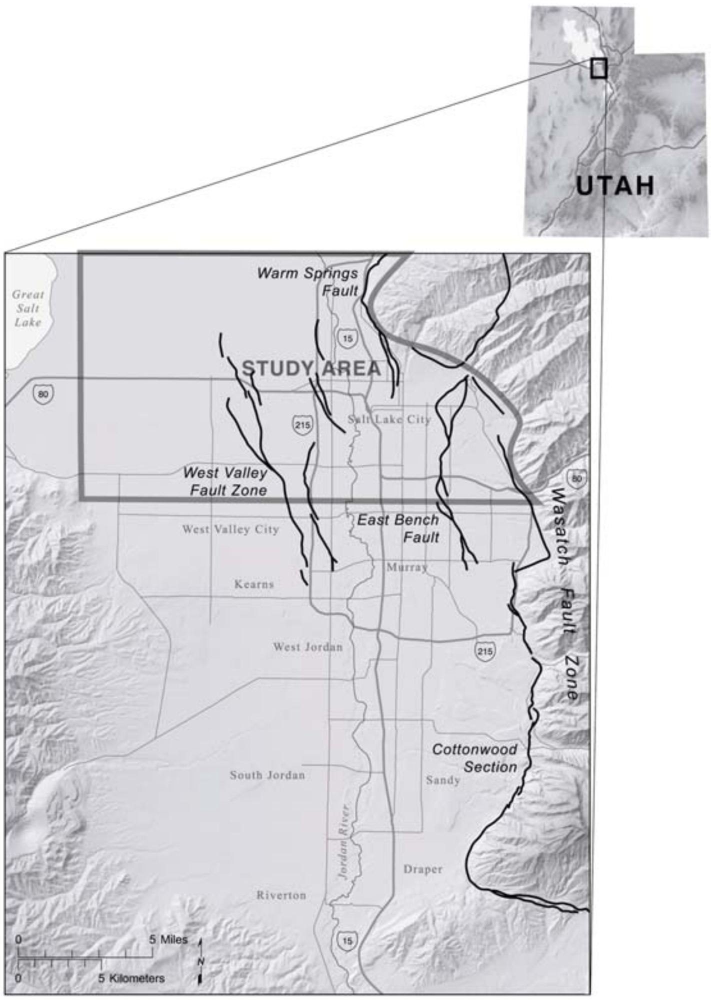


***Figure 1.*** *Map of Salt Lake Valley with study-area boundary.*

## RESULTS

Anderson and others (1986) previously mapped the liquefaction potential of Salt Lake Valley. Because geotechnical boreholes were clustered in urbanized areas and along major highways, Anderson and others (1986) devised a method to assess the liquefaction potential in areas lacking geotechnical data. They assessed the geologic and topographic settings of areas that had sufficient data, used these settings to estimate liquefaction potential in areas of sparse subsurface data, and adjusted liquefaction-potential boundaries after site-specific field checks of geology and topography.

The UGS will take advantage of new, detailed Quaternary geologic mapping and recent subsurface data compiled by the University of Utah to better assess geologic settings, adjust liquefaction-potential boundaries, and extend hazard mapping to areas having little or no subsurface data. The most detailed mapping in densely populated eastern Salt Lake Valley is a map of surficial geology along the Salt Lake City segment of the Wasatch fault zone, at a scale of 1:50,000 (Personius and Scott, 1992). The UGS recently mapped the geology of three 7½-minute quadrangles in western Salt Lake Valley (Biek and others, 2004) at a scale of 1:24,000. Although significant amounts of subsurface geotechnical data have been generated throughout Salt Lake Valley, their distribution is uneven. Until recently, development was concentrated on the east side of the valley and this is where most subsurface data are found. In recent years development has extended westward, and more data are now available in this area where Anderson and others (1986) had virtually none.

Our preliminary results show that liquefaction susceptibility in many areas depends on subsurface geology rather than surficial geologic units. Most surficial deposits in our study area are of Holocene age, with varying susceptibility to liquefaction. The Jordan River flows northward through the eastern part of the area into Great Salt Lake, and associated saturated, sandy alluvium and deltaic deposits are highly susceptible. Much of the remaining surficial deposits are finer grained Holocene marsh and lacustrine sediment of lower susceptibility. However, the surficial deposits are typically less than 15 feet thick. Offshore deposits of latest Pleistocene Lake Bonneville underlie the Holocene units and are saturated at shallow depths. The underlying Bonneville deposits in the study area are commonly fine grained and have generally low liquefaction susceptibility but include interbedded clean, fine sands, several inches to several feet thick that have higher liquefaction susceptibility. In the eastern part of the study area, Bonneville sand and gravel is common at the surface and at liquefiable depths, but ground water is relatively deep. In the southwest corner of the study area at the base of the Oquirrh Mountains, a thin veneer of Bonneville gravel overlies pre-Bonneville Pliocene to Pleistocene alluvial-fan deposits too dense to liquefy.

## NON-TECHNICAL SUMMARY

The urban Wasatch Front of Utah may be subject to liquefaction during strong earthquakes from active faults in the region. During liquefaction, granular soils saturated by shallow ground water change from a solid to a liquid, which may result in damage or loss of life. The Utah Geological Survey is participating in a collaborative study to develop techniques for mapping the local liquefaction potential by identifying representative characteristics of geologic units contributing to liquefaction. Preliminary results indicate thin sand layers interbedded in clay deposited by Lake Bonneville thousands of years ago are widespread and may contribute to higher liquefaction hazards.

## REPORTS PUBLISHED

No reports related to this project have been published yet. We anticipate that the Utah Geological Survey will publish the final technical report, and study results will be presented at meetings of various professional organizations.

## AVAILABILITY OF PROCESSED DATA

The geotechnical database compiled for this project by the University of Utah is available in digital form on the Internet at http://www.civil.utah.edu/~bartlett/ulag.html. The contact person at the University of Utah is:

Dr. Steven F. Bartlett
Telephone: (801) 587-7726
E-mail: bartlett@civil.utah.edu

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